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(54) Power feed line switching circuit for submarine branching device and method of feeding power to submarine cable communication system

(57) A power feed line switching circuit for a submarine branching unit including a first, second and third terminals (301, 302, 303), a first and second power feed lines (304a, 304b) for both-end power feed between th first and second terminals (301, 302), and a third power feed line (305) for one-end power feed between the third terminal (303) and a ground, and a plurality of relays for controlling DC insulation resistance test to the inspection of the power feed lines, wherein the plurality of relays comprises a first relay (306) including a drive means (306L) inserted in the first power feed line (304) and a switching means (306C) inserted in the second power feed line (305) to disconnect the third terminal (303) from the ground when the first relay (306) is de-energized and to ground the third terminal (303) when the first relay (306) is energized.

Fig. 9

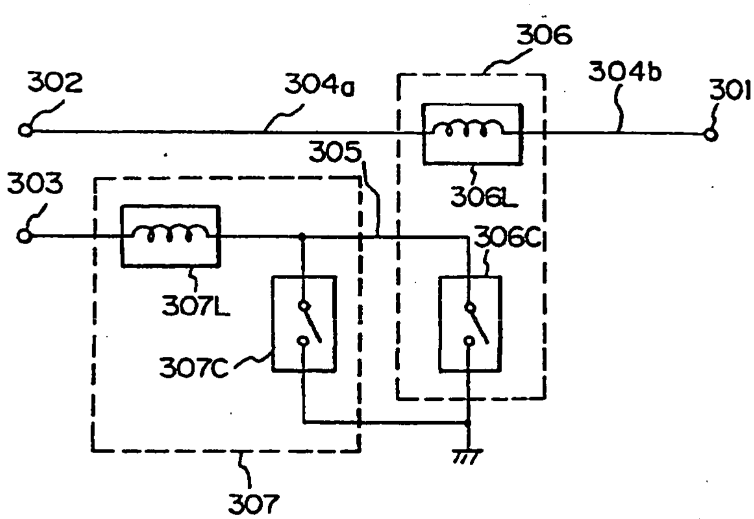

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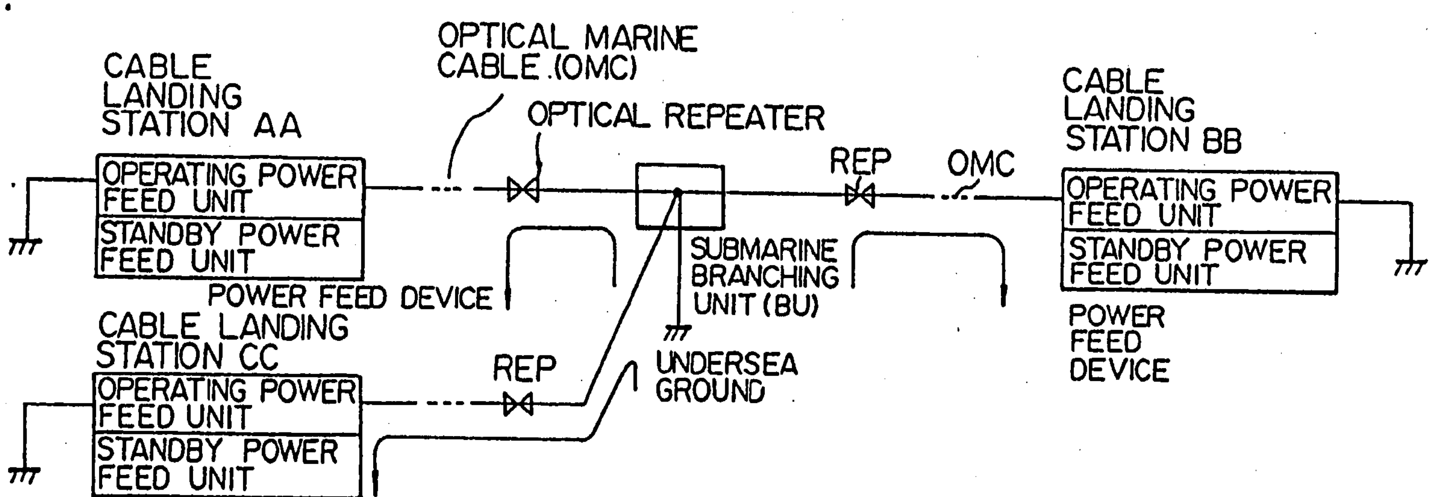
Fig. 1



ONE-END POWER FEED SYSTEM

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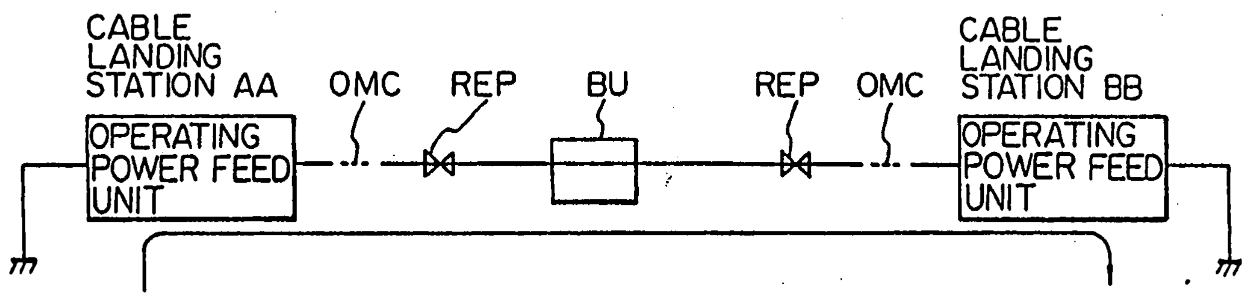
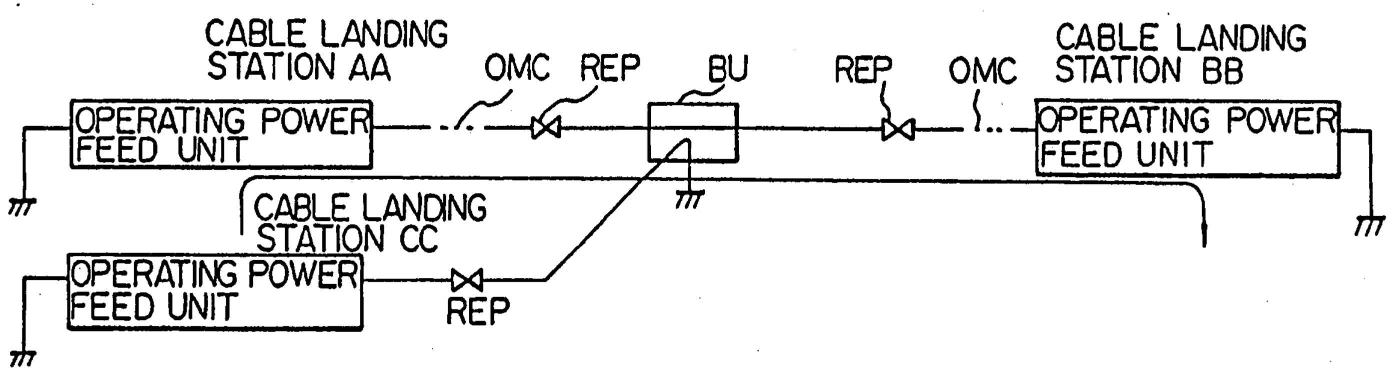
Fig. 2



BOTH-END POWER FEED SYSTEM

Fig. 3



ONE-END AND BOTH-END
POWER FEED SYSTEM

Fig. 4

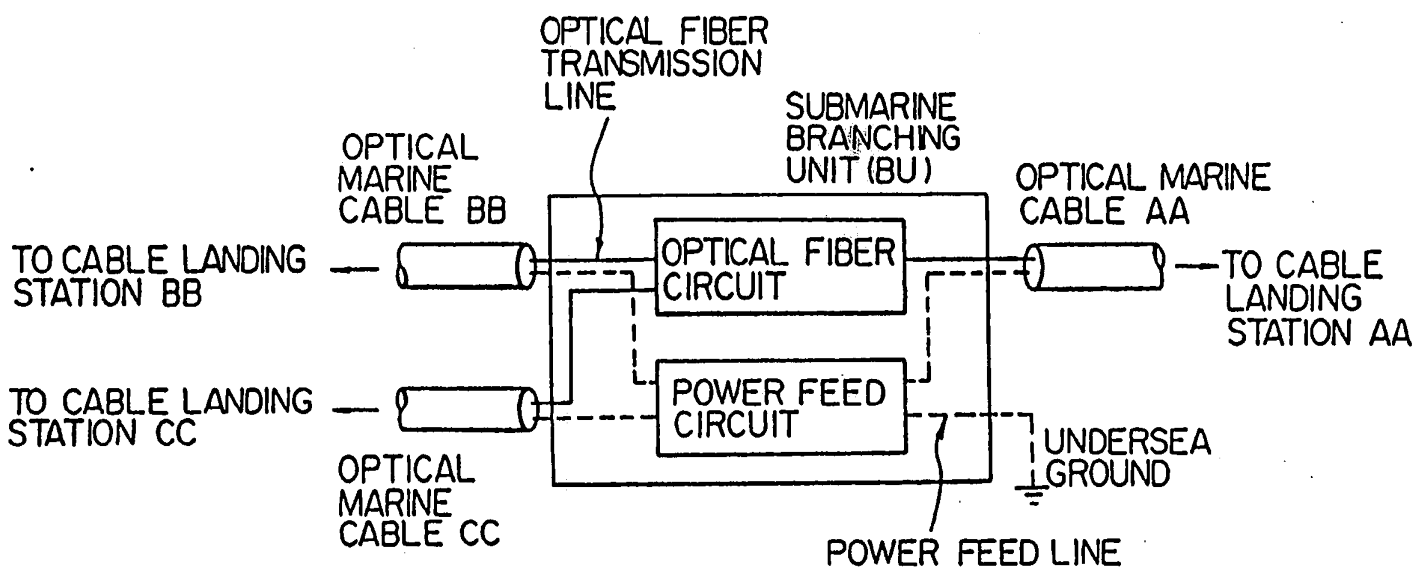

OPTICAL FIBER TRANSMISSION LINE
SUBMARINE BRANCHING UNIT (BU)
OPTICAL MARINE CABLE BB
OPTICAL MARINE CABLE AA
TO CABLE LANDING STATION BB
OPTICAL FIBER CIRCUIT
TO CABLE LANDING STATION AA
TO CABLE LANDING STATION CC
POWER FEED CIRCUIT
UNDERSEA GROUND
OPTICAL MARINE CABLE CC
POWER FEED LINE

Fig. 5A

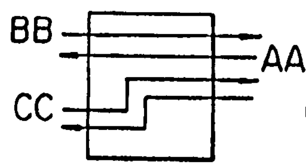


Fig. 5B

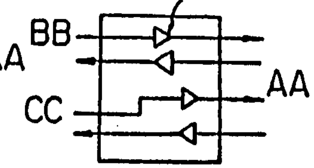


Fig. 5C

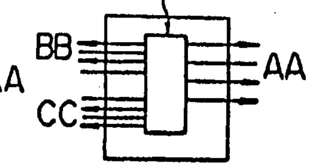


Fig. 5D

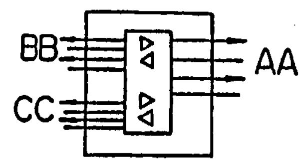


Fig. 5E

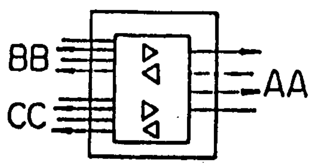


Fig. 5F

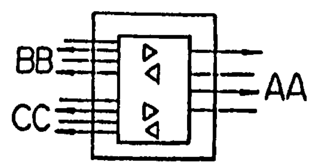


Fig. 6 PRIOR ART

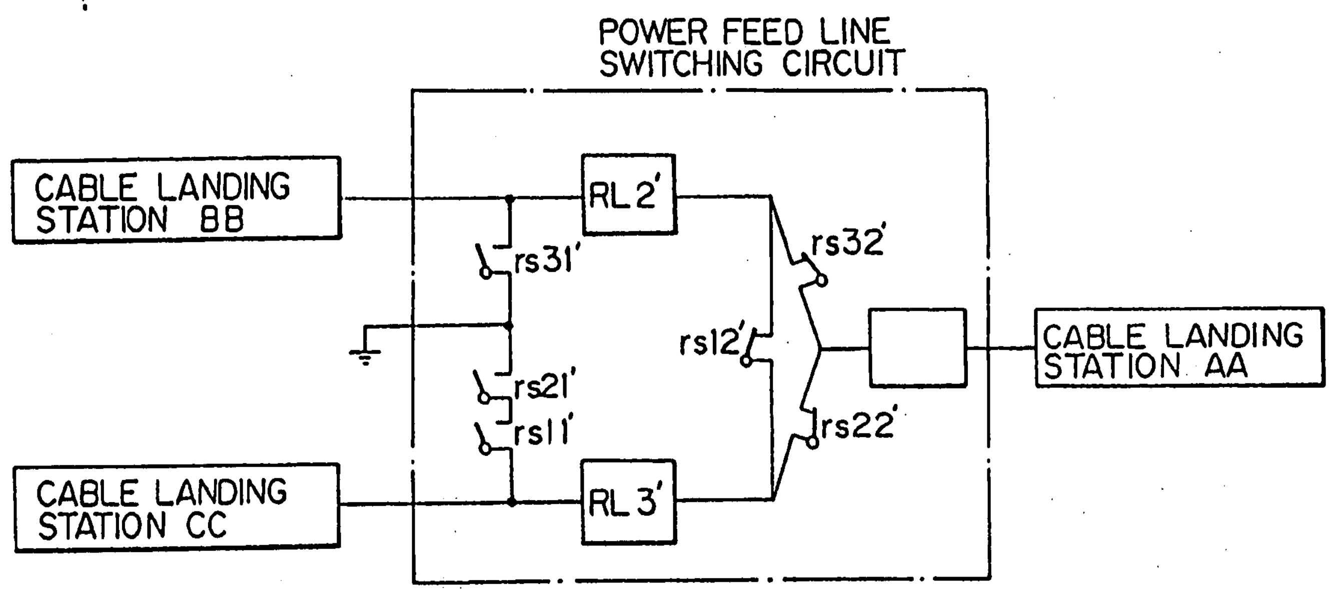


Fig. 7 PRIOR ART

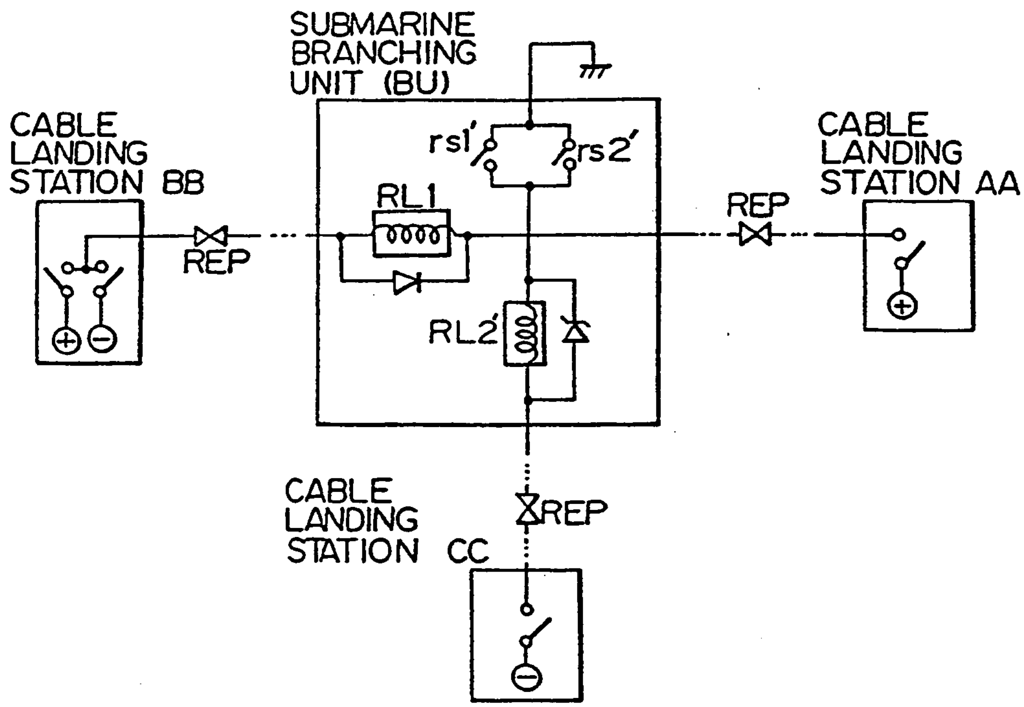


Fig. 8 PRIOR ART

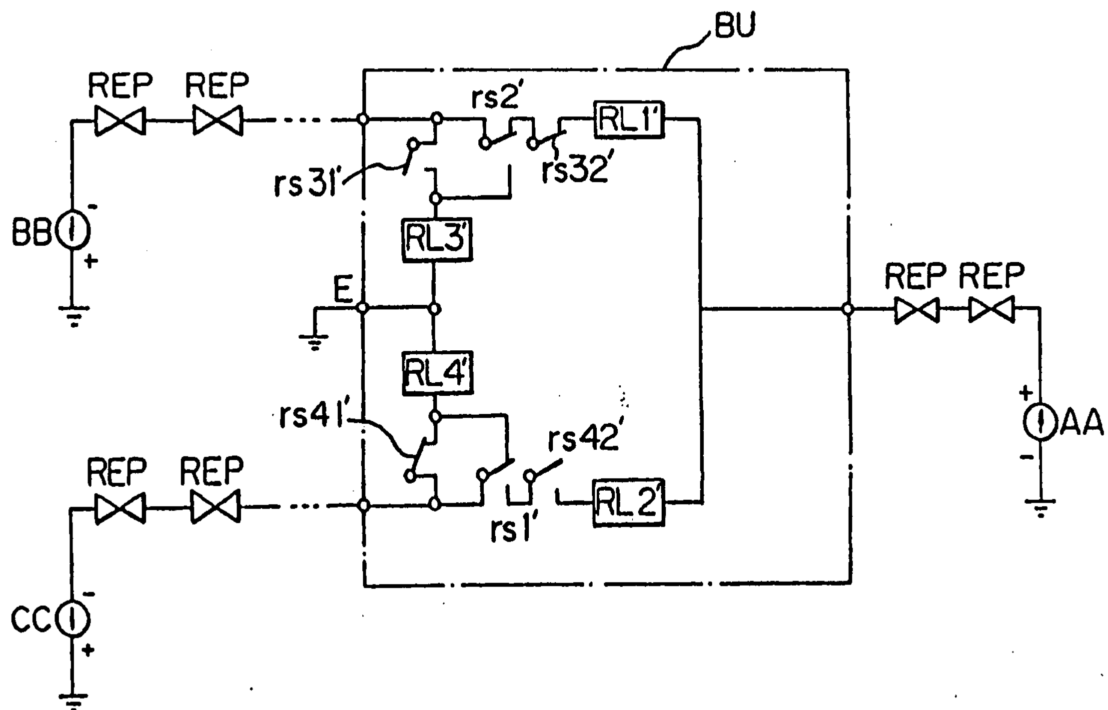


Fig. 9

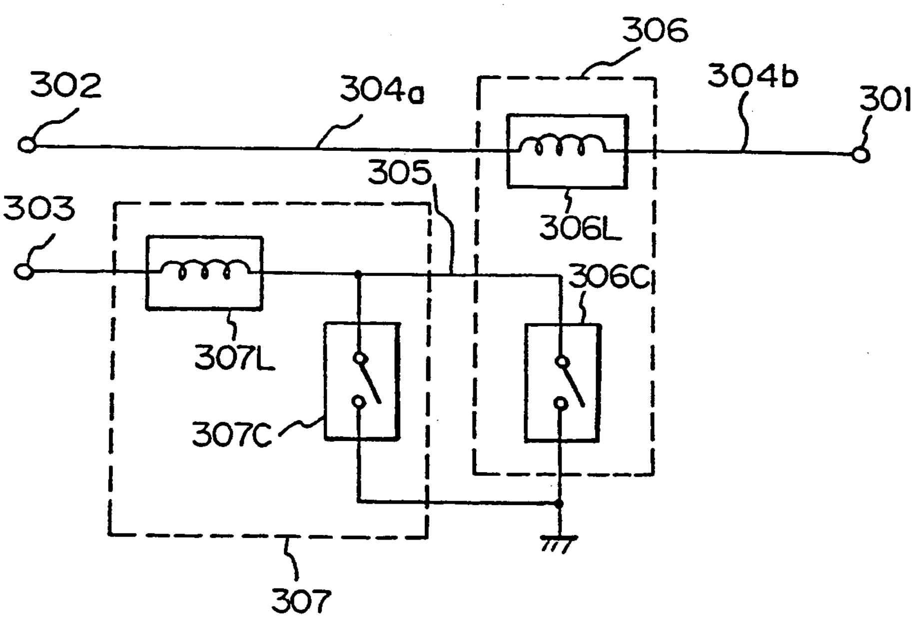


Fig. 10

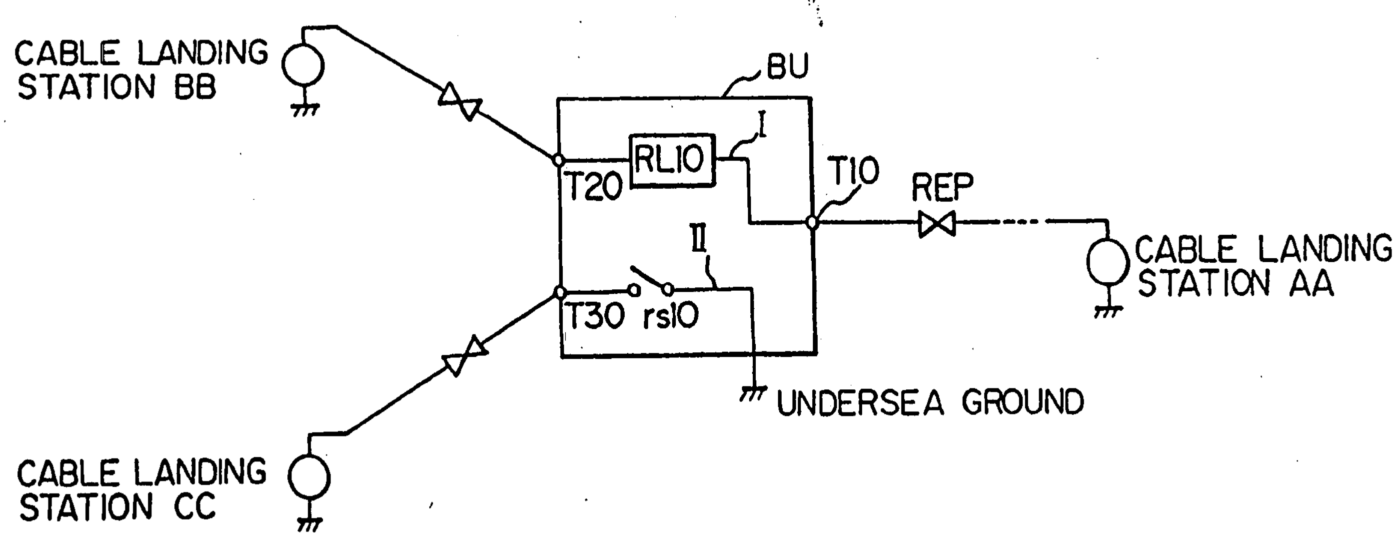
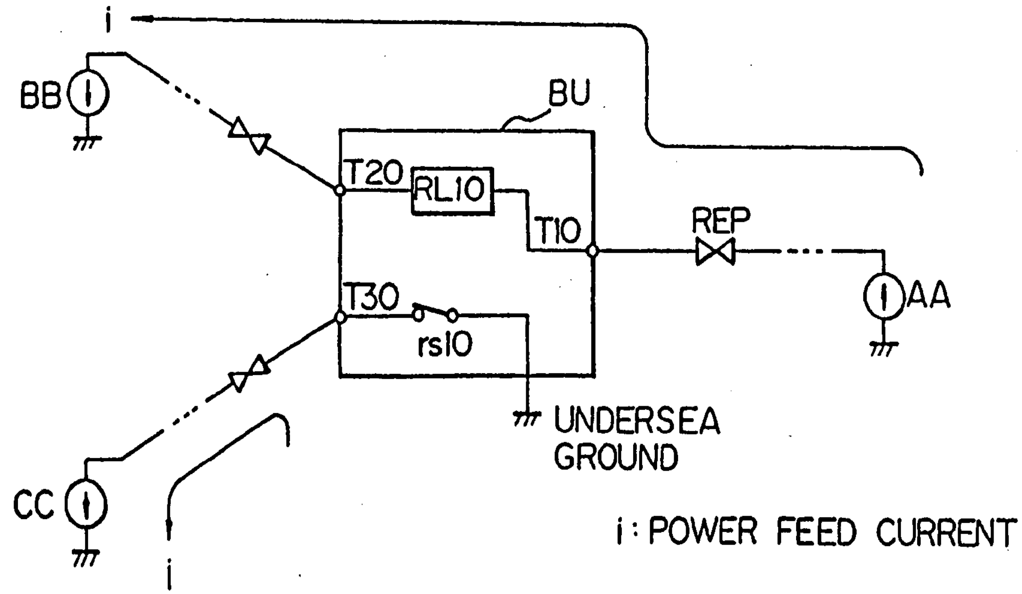

CABLE LANDING
STATION BB
CABLE LANDING
STATION CC
BU
RL10
I
T20
II
T30
rs10
T10
REP
CABLE LANDING
STATION AA
UNDERSEA GROUND

Fig. 11


i
BB
CC
BU
T20
RL10
T10
T30
rs10
REP
AA
UNDERSEA
GROUND
i
i : POWER FEED CURRENT

12/19

Fig. 12

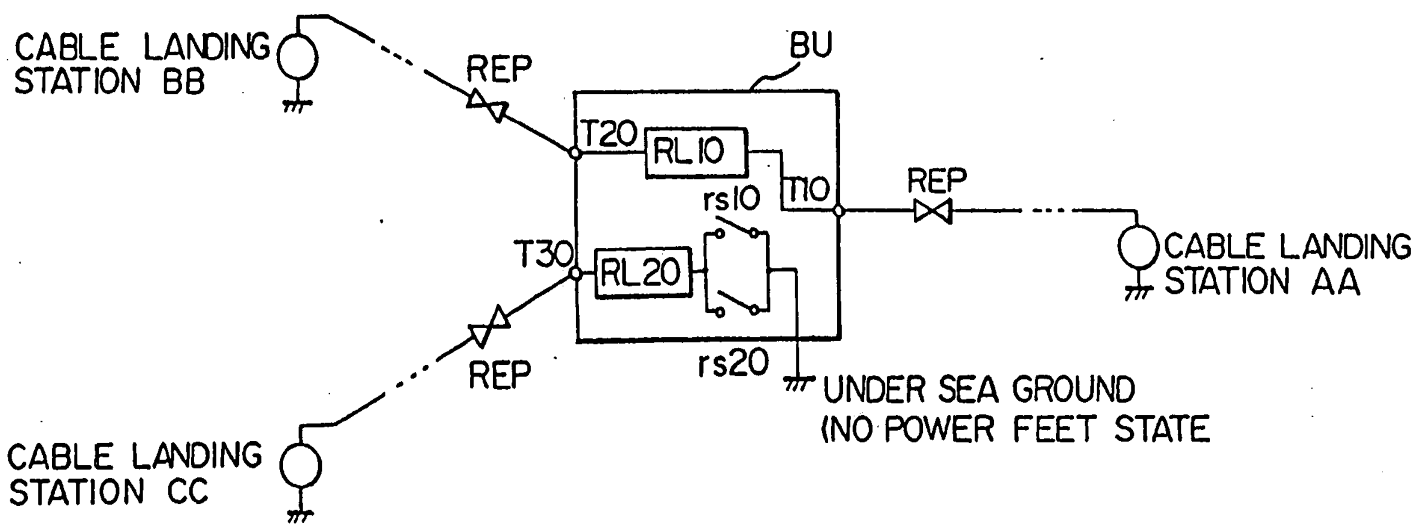
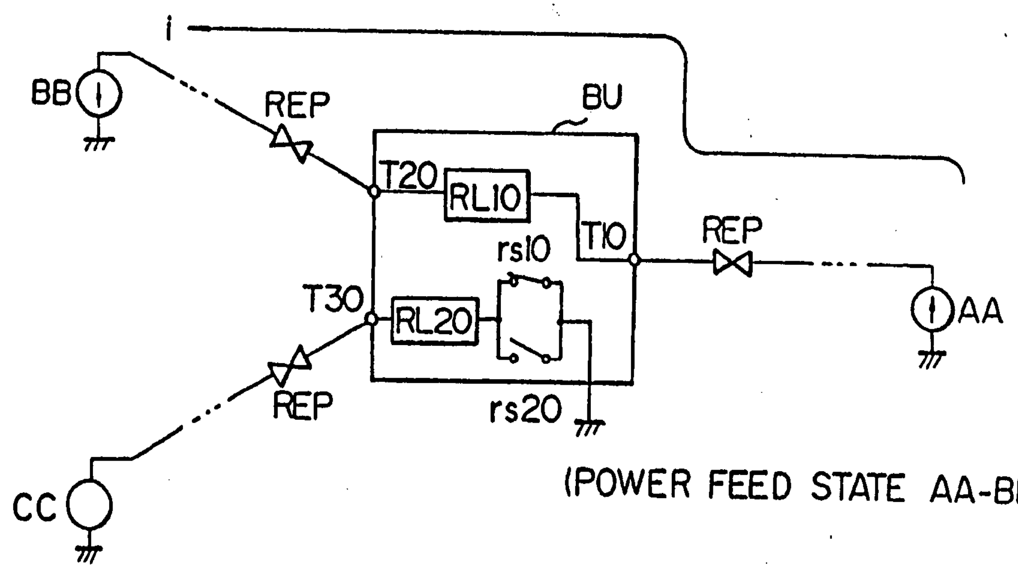
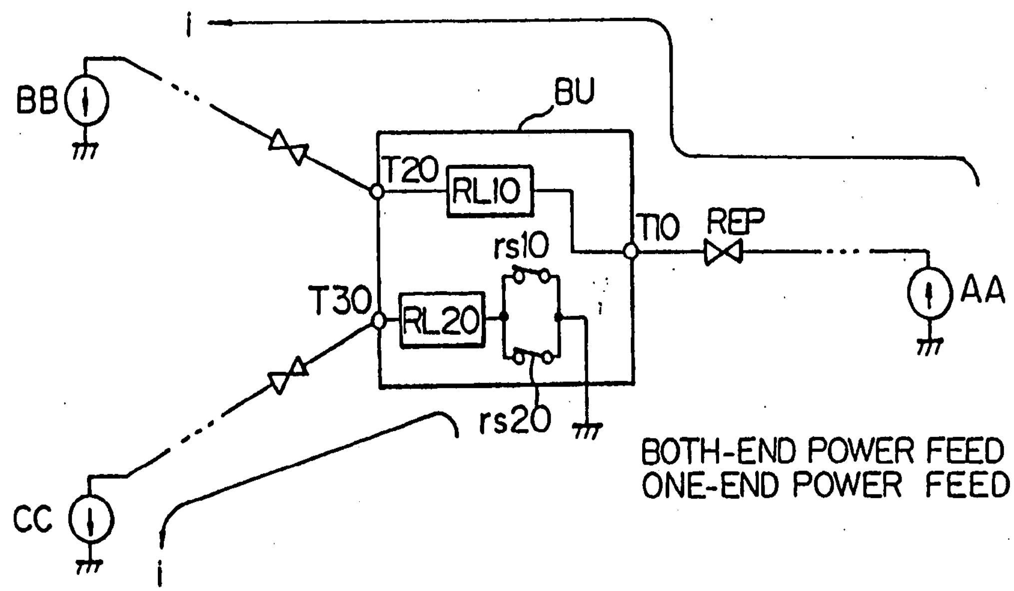

CABLE LANDING STATION BB
CABLE LANDING STATION CC
CABLE LANDING STATION AA
REP
REP
REP
BU
T10
T20
T30
RL10
RL20
rs10
rs20
UNDER SEA GROUND
(NO POWER FEET STATE

Fig. 13



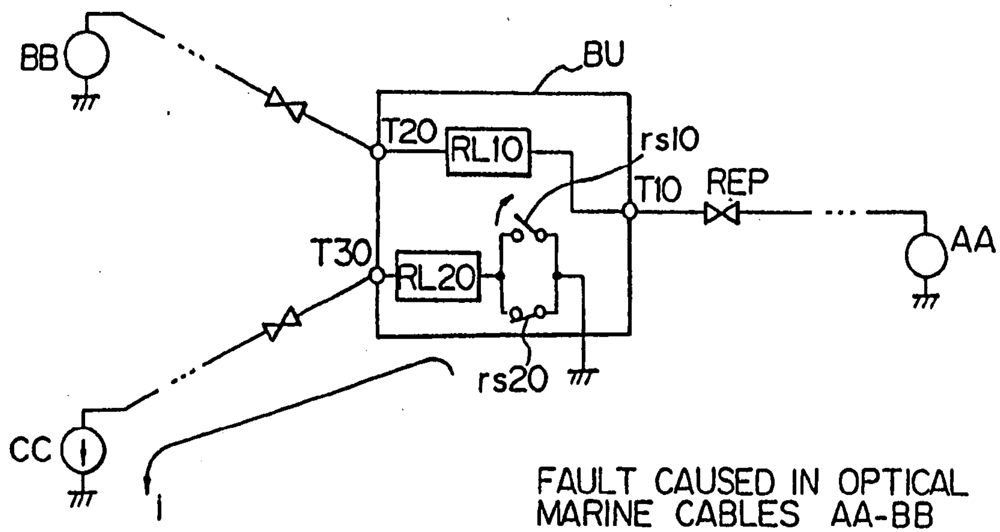
(POWER FEED STATE AA-BB

Fig. 14



BOTH-END POWER FEED MODE AA-BB
ONE-END POWER FEED MODE CC

Fig. 15



FAULT CAUSED IN OPTICAL
MARINE CABLES AA-BB

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Fig. 16

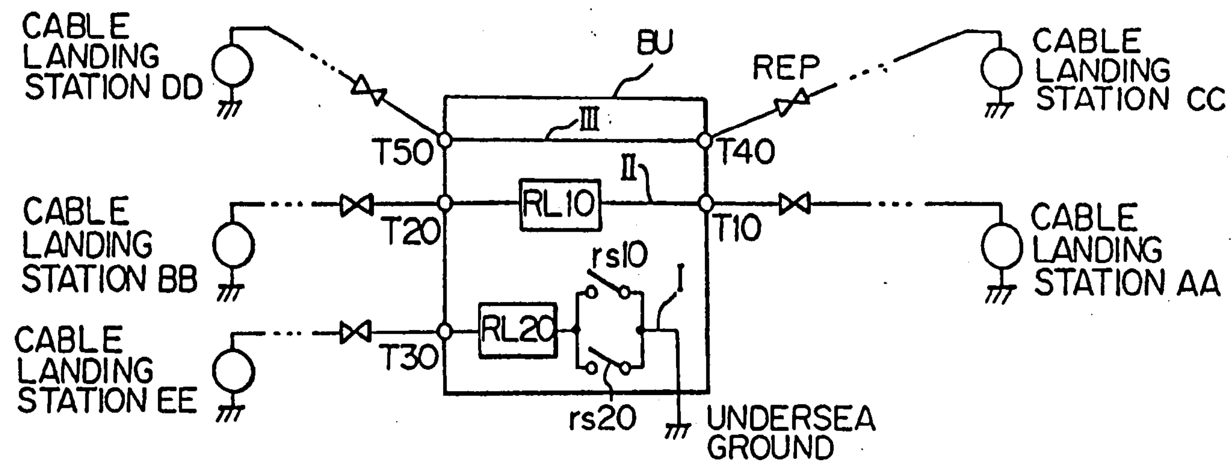

CABLE LANDING STATION DD
CABLE LANDING STATION BB
CABLE LANDING STATION EE
CABLE LANDING STATION CC
CABLE LANDING STATION AA
BU
REP
III
II
I
T50
T40
T20
T10
T30
RL10
RL20
rs10
rs20
UNDERSEA GROUND

Fig. 17

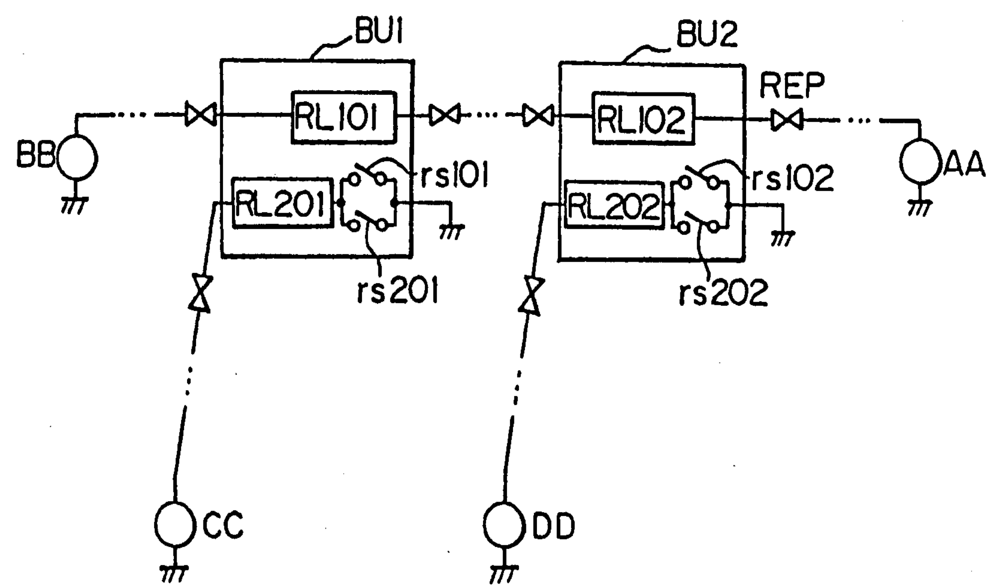

BU1
BU2
REP
RL101
RL102
RL201
RL202
rs101
rs102
rs201
rs202
AA
BB
CC
DD

Fig. 18

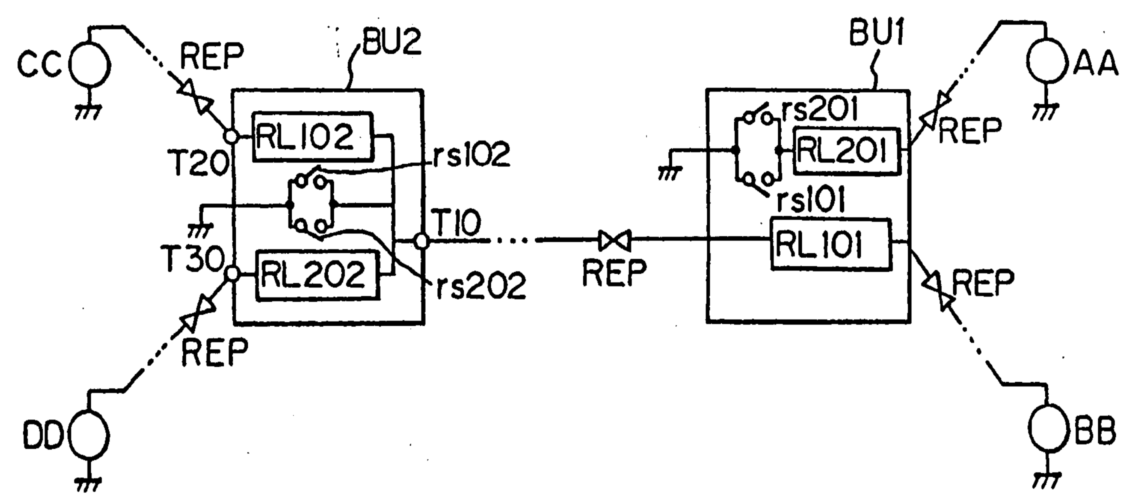
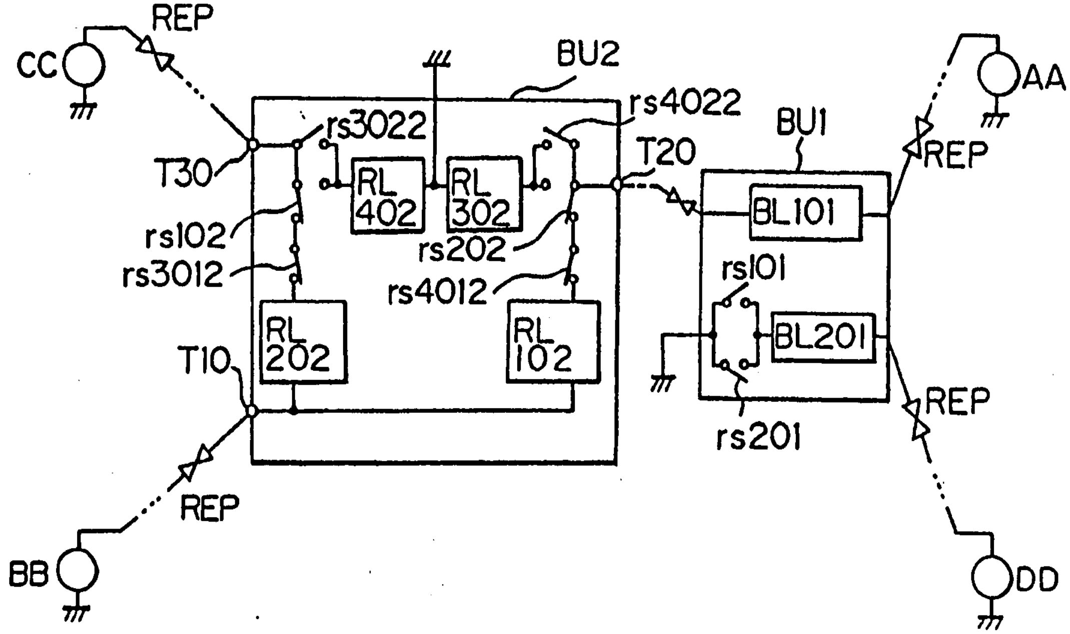

CC
REP
BU2
RL102
T20
rs102
T10
T30
RL202
rs202
REP
DD
REP
BU1
rs201
RL201
AA
REP
rs101
RL101
REP
BB

Fig. 19



CC
REP
BU2
rs3022
rs4022
BU1
AA
T30
RL 402
RL 302
T20
BL101
REP
rs102
rs202
rs3012
rs4012
rs101
RL 202
RL 102
BL201
T10
REP
rs201
REP
BB
DD

2280341

POWER FEED LINE SWITCHING CIRCUIT FOR SUBMARINE BRANCHING DEVICE AND METHOD OF FEEDING POWER TO SUBMARINE CABLE COMMUNICATION SYSTEM

The present invention relates to a power feed line switching circuit for a submarine branching device and a method of feeding power to a submarine cable communication system, more particularly, to a power feed line switching circuit for a submarine branching unit incorporated into a submarine cable communication system in which submarine cables are branched undersea to enable communication between three or more land stations, and further, to a method of feeding power employing the power feed line switching circuit.

Generally, a submarine cable communication system, particularly, a submarine optical communication system using optical marine cables (OMC) is provided with optical repeaters (REP) at specific intervals in each of the optical marine cable. Note, in the prior art, a one-end power feed system (mode) and a both-end power feed system have been used in the submarine optical communication system.

A constant DC current is supplied through a power feed line of the optical marine cable to the optical repeaters. The DC current is supplied to the optical repeaters in either the one-end power feed mode in which the DC current is supplied from only one land station or the both-end power feed mode in which the DC current is supplied from two land stations. The both-end power feed mode is preferable because of a high reliability, and it is preferable to switch the power feed line when a fault occurs in the power feed line so that a set power feed line is a both-end power feed line, as much as possible.

In the one-end power feed system of three cable landing stations of the prior art, respective power feed units of the three cable landing stations are connected individually by power feed lines to a submarine branching

unit (BU), and power is fed in the one-end power feed mode only from each of the cable landing stations to the submarine branching unit and the repeaters.

The conventional submarine optical cable communication system including three or more cable landing stations sets a power feed line by changing the power feed line switching circuit of the submarine branching unit for one-end power feed or both-end power feed. Note, the conventional power feed line switching circuits for a submarine optical cable communication system communicating between three or more cable landing stations are, for example, disclosed in Unexamined Japanese Patent Publication (Kokai) Nos. 2-53332, 1-200832, 1-276937 and 63-189025 (corresponding to U.S. Patent No. 4,798,969 and G.B. Patent No. 2,202,110). The configurations and problems of these prior art power feed line switching circuits will be explained later with reference to the accompanying drawings.

The present application is a divisional of co-pending British Patent Application No. 9114330.5 (Publication No. GB-2,202,110A) which describes and claims a power feed switching circuit for a submarine branching unit having a first, second and third electrical paths connected in Y-shaped connect, a first, second and third terminals connected respectively to the ends of the electrical paths to connect the electrical paths to the power feed lines of optical marine cables, and a plurality of relays for controlling the connections between the terminals and the electrical paths, for establishing a one-end power feed line or a both end power feed line to maintain power feed for repeaters and the submarine branching unit by a plurality of relays, even though a fault is caused in the optical marine cables for cable landing stations.

According to a first aspect of the present invention, a power f ed line switching circuit for a submarine branching unit having a first, second and third terminals, a first and second power feed lines for both-end power feed between said first and second terminals, and a third power

feed line for one-end power feed between said third terminal and a ground, and a plurality of relays for controlling DC insulation resistance test to the inspection of said power feed lines, is characterised in that said plurality of relays comprises:

a first relay including a drive means inserted in said first power feed line; and

a switching means inserted in said second power feed line to disconnect said third terminal from the ground when said first relay is de-energized and to ground said third terminal when said first relay is energized.

The power feed line switching circuit may further comprise a second relay including a drive unit inserted in a grounding line between the third terminal and the ground, and a switching unit connected in parallel to the switching unit of the first relay to form a lock-up circuit in the grounding line.

According to a second aspect of the present invention, there is provided a method of feeding power to a submarine cable communication system having a submarine branching unit for branching optical marine cable to inter-connect three or more land stations, each land station having a power feed unit having a power polarity changing unit, and the submarine branching unit includes a power feed line switching circuit.

In a first embodiment of the second aspect of the present invention, the method comprises the step of: forming a power feed line by feeding power in the both-end power feed mode between the cable landing stations connected respectively to the first and second terminals of the power feed line switching circuit, and then feeding power in the one-end power feed mode by the cable landing station connected to the third terminal.

In a second embodiment, the method comprises the step of: forming a main power feed line by connecting the first pow r feed lines of the power feed line switching circuits included in the plurality of submarine branching units in

a series connection, and forming a power feed line by feeding power in the both-end power feed mode between the cable landing stations connected respectively to the ends of the main power feed line, and then feeding power in the one-end power feed mode by the cable landing stations connected respectively to the respective third terminals of the power feed line switching units.

The power feed line switching circuit may further comprise a second relay including a drive unit inserted in a grounding line between the third terminal and the ground, and a switching unit connected in parallel to the switching unit of the first relay to form a lock-up circuit in the grounding line.

Embodiments of the present invention will now be described with reference to the accompanying drawings, in which:-

Figure 1 is a diagram for explaining a one-end power feed system according to the prior art;

Figure 2 is a diagram for explaining a both-end power feed system according to the prior art;

Figure 3 is a diagram for explaining a one-end and a both-end power feed system according to the prior art;

Figure 4 is a diagram for explaining the general construction of a submarine branching unit;

Figures 5A to 5F are diagrams showing various configurations of the optical fibre circuit shown in Figure 4;

Figures 6 to 8 are diagrams showing conventional power feed line switching circuits for a submarine optical cable communication system communicating between three or more cable landing stations;

Figure 9 is a diagram for explaining a principle of the present invention;

Figure 10 is a diagram showing a first embodiment of a power feed line switching circuit for a submarine branching unit according to the present invention;

Figure 11 is a diagram for explaining the operation of the power feed line switching circuit embodying the present invention;

Figure 12 is a diagram showing a second embodiment of a power feed line switching circuit for a submarine branching unit according to the present invention;

Figures 13 to 15 are diagrams for explaining the operation of the power feed line switching circuit shown in Figure 12;

Figure 16 is a diagram showing a third embodiment of a power feed line switching circuit for a submarine branching unit according to the present invention;

Figure 17 is a diagram showing a power feed system for a submarine cable communication system using two submarine branching units each incorporating a power feed line switching circuit in accordance with the present invention; and

Figures 18 and 19 are diagrams showing power feed systems for a submarine cable communication system using two submarine branching units respectively incorporating, in combination, a power feed line switching circuit in accordance with the present invention and a known power feed line switching circuit of the prior art.

Figure 1 is a diagram for explaining a one-end power feed system according to the prior art. As shown in Figure 1, cable landing stations AA and BB are connected by an optical marine cable OMC, optical repeaters REP are inserted at predetermined intervals, for example, about each hundreds kilometres, in the optical marine cable OMC, and a submarine branching unit BU is inserted in the optical marine cable OMC. The optical marine cable OMC is branched by the submarine branching unit BU to enable communication between three, or more cable landing stations.

Note, in the submarine optical cable communication system shown in Figure 1, the power feed lines of the optical marine cables OMC, which are connected to the cable

landing stations AA, BB and CC, are connected to the undersea ground, or connected to the sea at the submarine branching unit BU. Therefore, the respective power feed units of the cable landing stations AA, BB and CC are connected individually by power feed lines to the submarine branching unit BU, and power is fed in the one-end power feed mode only from the cable landing stations AA, BB or CC to the submarine branching unit BU and the repeaters REP.

In the one-end power feed system shown in Figure 1, if a power feed unit malfunctions while power is fed in the one-end power feed mode, it is impossible to feed power by a power feed unit other than the malfunctioning power feed unit. Therefore, the cable landing stations AA, BB and CC must be provided with standby power feed units and operating power feed units. Namely, each of the cable landing stations AA, BB and CC includes both currently operating power feed unit and standby power feed unit, respectively.

Figure 2 is a diagram for explaining a both-end power feed system according to the prior art. As shown in Figure 2, cable landing stations AA and BB are inter-connected by an optical marine cable OMC, and optical repeaters REP and a submarine branching unit BU are inserted in the optical marine cable OMC. In the both-end power feed mode, the power feed line between the cable landing stations AA and BB of the optical marine cable OMC is not connected to the undersea ground (or, the sea).

When the power feed unit of either the cable landing station AA or BB is of a positive polarity, the power feed unit of the other cable landing station is of a negative polarity. Therefore, power is fed to the power feed line of the optical marine cable (i.e., the submarine branching unit BU and the repeaters REP) from both the cable landing stations AA and BB. Therefore, in the both-end power feed mode, one of the power feed units feeds power to all the load in case the other power feed unit malfunctions and is unable to feed power, and hence th cable landing stations

need not be provided with standby power feed units. Namely, in the both-end power feed system shown in Figure 2, each power feed unit includes only the operating power feed unit and dose not include a standby power feed unit.

Consequently, in view of reliability, economy and operating voltage, the both-end power feed system is more preferable than the one-end power feed system.

Figure 3 is a diagram for explaining a one-end and both-end power feed system according to the prior art. As shown in Figure 3, in this power feed system, the power feed lines of submarine cables connected respectively to cable landing stations AA and BB are connected by a submarine branching unit BU without grounding the same for power feed between the cable landing stations AA and BB in the both-end power feed mode, and the power feed line of a submarine cable connected to a cable landing station CC is grounded undersea by the submarine branching unit BU to feed power in one-end power feed mode from the cable landing station CC.

Note, a submarine cable communication system, particularly, a submarine optical cable communication system using a optical marine cable (OMC), is provided with optical repeaters (REP) inserted at intervals in the optical marine cable. A constant DC current is supplied through a power feed line of the optical marine cable to the optical repeaters. The DC current is supplied to the optical repeaters in either a one-end power feed mode in which the DC current is supplied from only one land station or a both-end power feed mode in which the DC current is supplied from two land stations. The both-end power feed mode is preferable because of its high reliability, and it is preferable to switch the power feed line when a fault occurs in the power feed line so that a set power feed line is a both-end power feed line as much as possible.

Figure 4 is a diagram for explaining the general construction of a submarine branching unit. As shown in Figure 4, the submarine branching unit BU mainly comprises

an optical fibre circuit and a power feed circuit. The optical fibre circuit is inserted in the optical fibre transmission line of the optical marine cable, and the power feed circuit is inserted in the power feed line of the optical marine cable.

Figures 5A to 5F are diagrams showing various configurations of the optical fibre circuit shown in Figure 4. Three optical marine cables are connected to the submarine branching unit BU to inter-connect three cable landing stations AA, BB and CC. As shown in Figs. 5A to 5C, (a) the optical fibre circuit may be an optical fibre branching circuit (with reference to Figure 5A), (b) the optical fibre circuit may comprise an optical repeater circuit and an optical branching circuit (with reference to Figure 5B), and (c) the optical fibre circuit may comprise an optical branching/switching circuit (with reference to Figure 5C). Further, as shown in Figures 5D to 5F, (d) the optical fibre circuit may comprise an optical repeater circuit and an optical branching/switching circuit (with reference to Figure 5D), (e) the optical fibre circuit may comprise an optical repeater circuit and a multiplex converting circuit MUX and a demultiplex converting circuit DEMUX (with reference to Figure 5E), and (f) the optical fibre circuit may comprise an optical repeater circuit, an optical branching/switching circuit and a multiplex converting circuit MUX and a demultiplex converting circuit DEMUX (with reference to Figure 5F).

The conventional submarine optical cable communication system including three or more cable landing stations sets a power feed line by changing the power feed line switching circuit of the submarine branching unit for one-end power feed or both-end power feed.

Figures 6 to 8 are diagrams showing conventional power fe d line switching circuits for a submarine optical cable communication system to communicate between three or more cable landing stations. Namely, various power feed line switching circuits have been proposed, and Figs. 6 to 8

indicate configurations of power feed line switching circuits disclosed in Unexamined Japanese Patent Publication (Kokai) Nos. 2-53332, 1-200832 and 63-189025, respectively.

Namely, first, as shown in Figure 6, the power feed line switching circuit of Unexamined Japanese Patent Publication No. 2-53332, which is similar configuration of that shown in Figure 7, is capable of enabling communication between two optical marine cables even if a fault occurs in any one of three optical marine cables. However, this power feed line switching circuit has a complicated circuit configuration and needs a complicated power feed line setting procedure.

Next, the power feed line switching circuit of Unexamined Japanese Patent Publication No. 1-200832 shown in Figure 7 is capable of enabling communication between two of three optical marine cables connected to a submarine branching unit BU even if a fault occurs in any one of the three optical marine cables. However, since all the power feed lines are grounded by the submarine branching unit BU, each cable landing station is able to feed power only in a one-end power feed mode, and hence this system is unsatisfactory in reliability.

Further, the power feed line switching circuit of Unexamined Japanese Patent Publication 63-189025 shown in Figure 8 is currently put to practical use. If a fault occurs in one of two specified optical marine cables, namely, in an optical marine cable connected to a cable landing station BB or an optical marine cable connected to a cable landing station CC, a power feed line is changed to enable communication between the other two optical marine cables (CC-AA or AA-BB). However, if a fault occurs in a specified cable, for example, an optical marine cable connected to a cable landing station AA, it is impossible to form a power feed line between the other two optical marine cables (BB-CC) and the system becomes perfectly inoperative.

In addition, conventional submarine optical cable communication systems, in most cases, have transmission lines inter-connecting three cable landing stations, whereas submarine optical cable communication systems employing a plurality of submarine branching units to inter-connect more than three cable landing stations have been on the increase in recent years. Unexamined Japanese Patent Publication (Kokai) No. 1-276937 discloses a submarine optical power feed system for such a submarine optical cable communication system.

Next preferred embodiments of a power feed line switching circuit for a submarine branching device and a method of feeding power to a submarine cable communication system of the present invention will be described below, with reference to the accompanying drawings.

Figure 9 is a diagram for explaining a principle of the present invention.

A power feed line switching circuit for a submarine branching unit of the present invention comprises a first, second and third terminals 301, 302, 303 connected respectively to the power feed lines of optical marine cables, a first power feed line 304a, 304b formed between the first and second terminals 301, 302 for power feed in the both-end power feed mode, a second power feed line 305 formed between the third terminal 303 and the ground (undersea ground) for power feed in the one-end power feed mode. Further, the power feed line switching circuit comprises a first relay 306 having a drive unit 306L inserted in the first power feed line 304a, 304b and a switching unit 306C inserted in the second power feed line 305. Note, the switching unit 306C disconnects the third terminal 303 from the ground when the relay is de-energized and grounds the third terminal 303 when the relay is energized. Furthermore, the power feed line switching circuit of the present invention further comprises a second relay 307 having a drive unit 307L inserted in a grounding line between the third terminal 303 and the ground, and a

switching unit 307C connected in parallel to the switching unit 306C of the first relay 306 to form a lock-up circuit for the grounding line.

In the power feed line switching circuits in the third aspect of the present invention, the third terminal 303 is disconnected from the switching unit 306C of the first relay 306 from the ground, when no power is fed to isolate all the power feed lines in the power feed line switching circuit from seawater. Accordingly, it is possible to apply DC insulation resistance test to the inspection of the power feed lines of the submarine cables of the submarine cable communication system employing the power feed line switching circuit while no power is fed to the submarine cable communication system.

Figure 10 shows a power feed line switching circuit in a first embodiment according to the present invention for a submarine branching unit BU applied to a submarine optical cable communication system. In Figure 10, an optical circuit is omitted from the power feed line switching circuit.

Referring to Figure 10, the submarine branching unit BU has three terminals T10, T20 and T30 connected through the power feed lines of optical marine cables respectively to cable landing stations AA, BB and CC.

The terminals T10 and T20 are inter-connected within the submarine branching unit BU by a power feed line I, which is isolated from the ground (undersea ground). A relay RL10 has a driving coil inserted in the power feed line I, and a make contact rs10 inserted in a power feed line II connected to the ground. The terminal T30 is grounded through the make contact rs10 of the relay RL10 and the power feed line II. The relay RL10 is a high tension relay, such as a vacuum relay.

Power is fed in the both-end power feed mode between the two cable landing stations, i.e. the cable landing stations AA and BB, connected to the terminals T10 and

T20, and power is fed in the one-end power feed mode from the cable landing station CC connected to the terminal T30.

While no power is fed, the make contact rs10 of the relay RL10 is open to isolate the power feed lines of the submarine cables in the submarine branching unit from sea water (undersea ground), and hence it is possible to conduct DC insulation resistance test.

A method of feeding power from the cable landing stations AA, BB and CC to the optical marine cables by using the power feed line switching circuit will be described herein-after with reference to Figure 11.

In starting the operation, first power is fed in the both-end power feed mode between the cable landing stations AA and BB to energize the relay RL10 inserted in the power feed line I so that the make contact rs10 of the relay RL10 is closed to ground the terminal T30 connected to the cable landing station CC. Then, power is fed in the one-end power feed mode from the cable landing stations CC by using the ground of the submarine branching unit BU. In stopping power feed by a power feed stopping procedure, the one-end power feed by the cable landing station CC is stopped, and then the both end power feed between the cable landing stations AA and BB is stopped.

Figure 12 shows a power feed line switching circuit in a second embodiment of the present invention. In the power feed line switching circuit in the first embodiment, the relay RL10 is de-energized and the make contact r11 is opened if a fault occurs in the power feed line interconnecting the cable landing stations AA and BB during operation or if the power feed stopping procedure is carried out incorrectly, namely, if power feed between the cable landing stations AA and BB is stopped before stopping power feed from the cable landing station CC and, consequently, the power feed line of the submarine cable connected to the operating cable landing station CC is opened during constant current power feed. If the power feed line is opened during constant current power feed, a

high voltage is generated in the power feed line, which may possibly damage the associated equipment, such as an optical repeater. The power feed line switching circuit shown in Figure 12 is intended to solve such a problem.

The power feed line switching circuit shown in Figure 12 is different from that shown in Figure 11 in that the power feed line switching circuit shown in Figure 12 is provided, in addition to the components of the power feed line switching circuit shown in Figure 11, a relay RL2 having a drive unit inserted in the power feed line II connected to the cable landing station CC, and a break contact rs20 connected in parallel to the make contact rs10 of the relay RL10. The break contact rs20 forms a lock up circuit for the relay RL20.

As is obvious from Figure 12, the power feed lines of all the optical marine cables are isolated from sea water when no power is fed, so that DC insulation resistance test is possible.

The power feed start procedure to feed power to the power feed line switching circuit of Figure 13 will be explained with reference to Figure 13. First power is fed in the both-end power feed mode between the cable landing stations AA and BB to close the make contact r11 by energizing the relay RL10; consequently, the power feed line of the optical marine cable connected to the cable landing station CC is grounded undersea to enable the cable landing station CC to feed power.

Subsequently, as shown in Figure 14, power is fed in the one-end power feed mode by the cable landing station CC to close the break contact rs20 by energizing the relay RL20. Consequently, the grounding line II connecting the power feed line connected to the cable landing station CC to the ground is locked up by the relay RL20 as long as current is supplied to th power feed line connected to the cable landing station CC regardless of the condition of the make contact r11 of the relay RL10.

Accordingly, as shown in Figure 15, the power feed line connected to the cable landing station CC is not opened and hence no high voltage is generated in the power feed line even if the make contact rs10 of the relay RL10 is opened when power feed is interrupted due to the occurrence of a fault in the power feed line between the cable landing stations AA and BB while the cable landing stations AA, BB and CC are in operation.

In stopping power feed, the power feeding operation of the cable landing stations AA and BB is stopped after the power feed operation of the cable landing station CC has been stopped.

Figure 16 shows a power feed line switching circuit in a third embodiment of the present invention incorporated into a submarine branching unit branching five optical marine cables. The power feed line switching circuit shown in Figure 16 is provided, in addition to the components of the power feed line switching circuit shown in Figure 12, with terminals T40 and T50, and a both-end power feed line III extending between the terminals T40 and T50.

Figure 17 shows a power feed system for a submarine cable communication system inter-connecting four cable landing stations AA, BB, CC and DD by employing two submarine branching units BU1 and BU2 each provided with the power feed line switching circuit of Figure 12. In this power feed system, the power feed lines I of the respective power feed line switching circuits of the submarine branching units BU1 and BU2 are inter-connected by a submarine cable to form a both-end power feed line between the cable landing stations AA and BB. The cable landing stations CC and DD are connected to the submarine branching units BU1 and BU2, respectively, for power feed in the one-end power feed mode.

In carrying out a power feed procedure by the system of Figure 17, first power is fed in the both-end power feed mode between the cable landing stations AA and BB to ground undersea the power feed lines connected to the cable

landing stations CC and DD, and then the cable landing stations CC and DD feed power in the one-end power feed mode.

This power feed system may be provided with more submarine branching units to inter-connect more cable landing stations.

Figure 18 shows a power feed system for a submarine cable communication system inter-connecting four cable landing stations AA, BB, CC and DD by using two submarine branching units BU1 and BU2. The submarine branching unit BU1 incorporates the power feed line switching circuit of Figure 12.

Note, in the above, the submarine branching unit BU2 incorporates a known power feed line switching circuit such as disclosed in Unexamined Japanese Patent Publication (Kokai) No. 1-200832. The power feed line switching circuit of the submarine branching unit BU2 grounds all the power feed lines by feeding power across terminals T10 and T20 (or the terminal T10 and a terminal T30) to close the make contact rs102 (or rs202) by energizing a relay RL102 (or RL202).

The power feed system shown in Figure 18 using, in combination, the submarine branching units respectively incorporating the power feed line switching circuits of different circuit configurations is able, even if a fault occurs in the power feed line of a submarine cable, to keep the rest of the power feed lines of the submarine cables effective.

A power feed system shown in Figure 19 uses, in combination, power feed line switching circuits of different circuit configurations for the same purpose. In Figure 19, a submarine branching unit BU1 incorporates the power feed line switching circuit shown in Figure 12, and a submarine branching unit BU2 incorporates, for exampl , a known power feed line switching circuit disclosed in Japanese Patent Publication (Kokoku) No. 63-189025.

The power feed line switching circuit of the submarine branching unit BU2 feeds power in the both-end power feed mode through a submarine cable connected to terminal T10 and T20 (or a submarine cable connected to the terminal T10 and a terminal T30) to ground the power feed line of a submarine cable connected to the other terminal T30 (or T20) by the contact rs102 (or rs202) of a relay RL102 (or RL202) for power feed in the one-end power feed mode. Relays RL302 and RL402 form lock up circuits for the one-end power feed lines.

The electro-mechanical relays, such as vacuum relays, employed in the foregoing embodiments may be substituted by a contactless relays, such as solid state relays comprising semi-conductor switching elements instead of transfer contacts and make/break contacts.

In the present invention, the power feed lines within the submarine branching units are isolated from sea water and therefore the power feed lines of the submarine cable communication systems can be inspected by DC insulation resistance test. Furthermore, the power feed system employing the power feed line switching circuit in accordance with the present invention has the both-end power feed line and the one-end power feed line which are separated completely from each other and therefore the power feed units of the cable landing stations need not be provided with any special current control circuit for inverting the polarity of power to be fed, and power feeding operation can be achieved by a simple power feeding procedure.

CLAIMS

1. A power feed line switching circuit for a submarine branching unit having a first, second and third terminals (301, 302, 303), a first and second power feed lines (304a, 304b) for both-end power feed between said first and second terminals (301, 302), and a third power feed line (305) for one-end power feed between said third terminal (303) and a ground, and a plurality of relays for controlling DC insulation resistance test to the inspection of said power feed lines, characterised in that said plurality of relays comprises:

a first relay (306) including a drive means (306L) inserted in said first power feed line (304); and

a switching means (306C) inserted in said second power feed line (305) to disconnect said third terminal (303) from the ground when said first relay (306) is de-energized and to ground said third terminal (303) when said first relay (306) is energized.

2. A power feed line switching circuit for a submarine branching unit as claimed in claim 1, wherein said power feed line switching circuit further comprises a second relay (307) including a drive means (307L) inserted in a grounding line between said third terminal (303) and the ground, and a switching means (307C) connected in parallel to the switching means (306C) of said first relay (306) to form a lock-up circuit in the grounding line.

3. A method of feeding power to a submarine cable communication system having a submarine branching unit for branching optical marine cables to inter-connect three or more land stations (AA, BB, CC), each land station having a power feed unit having a power polarity changing unit, and said submarine branching unit includes a power feed line switching circuit as claimed in claims 1 or 2, characterised in that said method comprises:

a step of forming a power feed line by f eding power in said both-end power feed mode between said cable landing

stations connected respectively to said first and second terminals (301, 302) of said power feed line switching circuit, and then feeding power in said one-end power feed mode by said cable landing station connected to said third terminal (303).

4. A method of feeding power to a submarine cable communication system having a submarine branching unit for branching optical marine cables to inter-connect four or more land stations (AA, BB, CC, DD), each land station having a power feed unit having a power polarity changing unit, and said submarine branching unit includes a power feed line switching circuit as claimed in claims 1 or 2, characterised in that said method comprises:

a step of forming a main power feed line by connecting said first power feed lines of said power feed line switching circuits included in said plurality of submarine branching units in a series connection, and forming a power feed line by feeding power in said both-end power feed mode between said cable landing stations connected respectively to said ends of said main power feed line, and then feeding power in said one-end power feed mode by said cable landing stations connected respectively to said respective third terminals of said power feed line switching means.

5. A method of feeding power to a submarine cable communication system having a submarine branching unit for branching optical marine cables to inter-connect four or more land stations (AA, BB, CC, DD), each land station having a power feed unit having a power polarity changing unit, and said submarine branching unit includes a power feed line switching circuit as claimed in claims 1 or 2, wherein said power feed line switching circuit and another power feed line switching circuit are employed thereto.